

Mutual Exclusivity and Exclusion: Converging Evidence From Two Contrasting Traditions

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Mutual exclusivity and exclusion are two terms used by cognitive psychologists and behavior analysts, respectively, to identify essentially the same phenomenon. While cognitive psychologists view mutual exclusivity in terms of a hypothesis that individuals use intuitively while acquiring language, behavior analysts regard exclusion as a derived stimulus relation that bears upon the acquisition and elaboration of verbal behavior. Each research tradition, though at odds with respect to accounting for the phenomenon, employs similar procedures to answer comparable questions. Insofar as both cognitive and behavioral psychologists are studying the same phenomenon, the ground work is established for collaboration between them.

When children are shown two objects, one familiar and the other unfamiliar, in the sense that they can name one correctly but not the other, and are then given a novel name and asked to assign it to one of the objects, they will ordinarily attach the novel name to the unfamiliar object. This phenomenon has been identified in the cognitive psychology literature as "mutual exclusivity" (Markman, 1989). Essentially the same outcome has been identified by behavior analysts as "exclusion" (McIlvane & Stoddard, 1981). These designations aside, cognitive and behavior analytic psychologists agree that the significance of this phenomenon lies in its importance to linguistic development.

We shall see that while research methods are relatively easy to compare, outcome measures present a formidable interpretive problem. All of the familiar philosophical issues are involved here (see Morris, Higgins, & Bickel, 1982), as are issues of a more methodological sort. On this latter score, part of the problem is that cognitive psychologists typically rely on a few observations of large numbers of subjects whose performances are averaged and then submitted to inferential statistical

analyses having a litany of mathematical assumptions. Shunning these tactics (see Michael, 1974), behavior analysts rely instead on single-case research methods having only the requirement that an individual's behavior be observed and recorded accurately, repeatedly, and reliably over time (Johnston & Pennypacker, 1993a). Furthermore, visual inspection of the stability, level, and trend in the data serves as the primary means for analyzing behavior change.

The differences can also be illustrated at a conceptual level. On this score, the world views of cognitivism and radical behaviorism are different. Cognitivism can be seen as essentially a mechanistic world view whereas radical behaviorism is primarily a contextualistic position (Hayes, Hayes, & Reese, 1988). Given the nature of world views, each can be examined with respect to their internal coherency while comparisons between world views are difficult, if not impossible (Pepper, 1942). Thus, cognitive and behavioral accounts of mutual exclusivity and exclusion can only be legitimately examined within each perspective. The upshot of this is that different world views influence both how the questions are asked and, more importantly, what types of questions and answers qualify as important.

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Keeping in mind the threat that these philosophical and methodological differences pose to interpretation (Johnston & Pennypacker, 1993b), comparing outcomes generated by the respective experimental preparations nevertheless can be both revealing and instructive. It can also be constructive in that numerous research opportunities seem available to cognitive and behavior analytic psychologists for collaborative work in this area of human verbal behavior.

Our purpose in this paper is to (a) review the cognitive literature on mutual exclusivity, (b) review the behavior-analytic literature on exclusion, and (c) provide suggestions on how behavior analysts may profit from the research conducted on mutual exclusivity as well as show how collaboration might take place. Consequently, our paper is divided into four sections. In the first section, we examine the cognitive psychology literature on mutual exclusivity. In this section, research on mutual exclusivity is divided into two subsections: age and level of development, and multiple labels and extensions. In the second section, the behavior analytic literature on exclusion is examined. This section is divided into three subsections: Exclusion I, Exclusion II, and Exclusion and Equivalence. The third section is titled "Research and Collaboration." Here the two research paradigms are brought together in that suggestions are provided to behavior analytic researchers (and indirectly to cognitive psychologists) on how to make use of the research in mutual exclusivity. Finally, it is shown how the two lines of research may effectively collaborate in applied settings.

MUTUAL EXCLUSIVITY

In order to lend perspective to the cognitive psychology literature on mutual exclusivity, it may be helpful to briefly review a few basic assumptions. To begin, cognitive psychology is based on an information processing model (Dodd & White, 1980). In this model, objects and events in the physical environment initially take the form of raw sensation. These are next transformed

into perception by various filtration processes which in turn activate relevant memory stores, central processing routines, and retrieval mechanisms, culminating in an observable response.

A common assumption within contemporary cognitive psychology is that individuals formulate rules which guide psychological activity (Markman, 1989, 1990; Golinkoff, Hirsh-Pasek, Baily, & Wenger, 1992). Cognitive psychologists are especially interested in delineating the rules and hypotheses involved in the acquisition and elaboration of language. That some of the rules involved are innate is reflected in a recent quote by Reich (1986), who in describing the view of current cognitive psychologists on this issue stated that "...children are born with certain specific language rules or strategies. These rules or strategies, when applied to the language children learn, allow them to construct a grammar for their language" (p. 283). One basic rule that young children are said to use in acquiring language is that every object has one and one label only. This is the rule that is said to underlie mutual exclusivity. According to Markman (1989), if children used the "mutual exclusivity rule" consistently, they "...would avoid redundant hypotheses about the meanings of category terms, and in many cases would be correct" (p. 188). Assuming that the "mutual exclusivity rule" emerges early in the life of an individual, it comes as no surprise that investigators have focused on children at different ages and levels of development. It is to that literature that we first turn.

Age and Level of Development

The earliest study in this area was by Vincent-Smith, Bricker, and Bricker (1974). They examined the effects of two training procedures on generating word-object relations. In one procedure, children between the ages of 20 and 31 months were first shown two objects with which they were unfamiliar. They were then given an unfamiliar word, and were asked next to attach one of the objects to the unfamiliar word. The children were given five sessions to

master the word-object pairs. A second procedure was similar to the first, with the important exception that one object was familiar to the child (i.e., the child already had acquired a name for the object) while the other object was unfamiliar. Table 1 provides an overview of the experimental design, which is fairly standard in studies of mutual exclusivity.

Table 1

Standard procedures in studies
of mutual exclusivity.

TRIAL TYPE	STIMULI	OUTCOMES
Regular Procedures	NS (NC, NC)	Word-Object Acquired More
Mutual Exclusivity	NS (NC, KC)	Quickly with M.E.
Learning Assessment	NSa (NCa, NC)	Subject Chose Original Pair
TRIAL TYPE	STIMULI	OUTCOMES
Mutual Exclusivity	NS (NC, KC, KC, KC)	Ss Chose NC

Key:

NS = Novel sample

KS = Known sample

NC = Novel comparison

KC = Known comparison

Example key: When the symbols NS (NC, KC) or A (B, C) are presented, the first symbol(s) in the brackets will be the correct choice (e.g., "NC" in the first case and "B" in the second).

The results showed that the second procedure generated correct word-object relations more rapidly and with less error than the first procedure. Another phase of the experiment examined whether or not the word-object relations established under the second procedure would be disturbed by introducing different unfamiliar objects to replace the familiar objects that the children did not select. This procedure had no effect on the word-object relations established under the second procedure. Taken together, these findings showed that juxtaposing familiar and unfamiliar word-object relations enhanced the acquisition of the latter. This, in effect, is mutual exclusivity, or rather, is evidence for the use of the nominal rule.

In another study involving children,

Hutchinson (1986) examined whether or not toddlers and slightly older children with and without mild retardation would show evidence for the mutual exclusivity rule when confronted with spoken words and objects. The children were divided into one of three age groups: 14-, 29-, 36-months. All were first shown pictures of paired objects, each pair consisting of an object that the children could and could not name. They were then presented with a spoken unfamiliar name and were asked to touch the corresponding object. Each pair of objects was presented twice, with a touch to the appropriate object being scored as correct when made on both trials. Hutchinson found that the three groups of normally developing children performed in ways consistent with the assumption that they were using the mutual exclusivity rule. She also found that performances improved as the age of the children increased. In the groups composed of children with mild retardation, the 29- and 36-month-olds performed at levels similar to their matched-age counterparts. In sharp contrast, the 14-month-old children with retardation scored at or below chance levels. The finding that young children with mild retardation did not employ the mutual exclusivity rule was interpreted as establishing a potential boundary condition for its use.

In a systematic replication of Hutchinson's (1986) study, Markman and Wachtel (1988) investigated the mutual exclusivity rule in terms of how it might guide children in limiting the meaning of words. In the first part of their study, Markman and Wachtel examined the differences between two groups of children. Given a novel name, three year-olds in the experimental group were shown an array of six objects, one unfamiliar, and all the others familiar. In the control group, the same sets of objects were presented, with the children being told simply to "choose one." Children in the experimental group chose the unfamiliar object in nearly five out of the six pairs. Children in the control group chose the unfamiliar object at chance levels.

In a methodologically innovative study, Merriman and Bowman (1989) used parent diaries as a means of documenting whether or not children had previously acquired the names for various objects. The aim of the research was to determine if two-to-four year-old children would attach an unfamiliar name to an object that they could already name, or to an object that they could not name (i.e., would use the mutual exclusivity rule). Children were divided into one of three age groups: 2-, 3-, and 4-years. Results indicated that only the 3- and 4-year-old children used the mutual exclusivity rule, with the latter group outperforming the former.

Merriman and Bowmen’s (1989) finding that the 2-year-olds in their study did not show use of the mutual exclusivity rule contrasted with Hutchinson’s (1986) results with her 14-month-old normally developing subjects. Thus the question arises, at what age do children first show the mutual exclusivity rule? Merriman and Schuster (1991) replicated the study by Merriman and Bowmen (1989), and found once again that 2-year-olds do make use of the mutual exclusivity rule. Thus, the weight of the evidence suggests that the mutual exclusivity rule is used by children as young as two years. Children at about the same age whose development is retarded, however, evidently do not use the rule.

Multiple Labels and Extensions

Assuming that the mutual exclusivity rule is an important factor in language acquisition, cognitive psychologists have proceeded to examine how the use of this rule relates to other factors involved in language. Markman and Wachtel (1988), in the second and third experiments of a study already mentioned, examined how use of the mutual exclusivity rule was affected when a novel name was attached to an object that the children could already name. Children were presented with novel words and were asked to choose whether the novel word referred to the object (e.g., cup) or to a quality of the object (e.g., red). When the object was unfamiliar, the children selected the novel word as a name for

the object. When the object was familiar, however, the children attached the novel word to the salient feature of the object. Subsequent experiments centered on how the mutual exclusivity rule might serve to guide children in assigning novel names to an object or to one of its features, depending on whether the object was or was not already named. As with previous experiments, when the object was unfamiliar, the children applied the novel word to it. When the object was already named, the children attached the novel word to the object’s salient feature. Table 2 summarizes the procedures followed by Markman and Wachtel.

Table 2
Mutual exclusivity with one
comparison stimulus.

TRIAL TYPE	STIMULI	OUTCOMES
Novel Comparison	NS (NC)	Name = Object
Known Comparison	NS (KC)	Name = Aspect or Feature of Object

In a series of experiments involving groups of monolingual (English) adults and monolingual and bilingual (English-Spanish) children, Au and Glusman (1990) investigated the relation between knowledge about hierarchical organization of categories (e.g., animal and cat) and cross-language equivalents (e.g., *pero* and dog). The study showed that both adults and children typically do not assign two novel names to the same object. Further results showed that by the age of four years, children allowed two names to refer to an object, provided that they belonged to different hierarchies (e.g., animal and lemur), and not to the same category (e.g., lemur and seal). Additionally, the monolingual and bilingual children evidently realized that an object could have more than one name, provided that the names were in different languages. The authors concluded that children’s and adults’ knowledge of categorization affects the mutual exclusivity rule when applied to learning new words.

Focusing on how noun and adjective usage might relate to whether an object being named was familiar or unfamiliar, Taylor and Gelman (1988) placed two-year-old children into one of two conditions: a noun condition and an adjective condition. Children in the noun condition heard, for example, "This is a 'tiv'"; children in the adjective condition heard, "This is a 'tiv' one." Whether the novel word was used as a noun or adjective was said to predict whether children would recognize it as a category or as a property of the object. Further, when the object was unfamiliar, children were expected to equate the new word with the new object. When the object being named already had a familiar label, however, the prediction was that they would consider alternatives to a category interpretation (for example, instead of equating the name with all objects in that category, they would only associate the name with that particular object).

Results showed that children who heard the novel words used as nouns responded to them as a category name, while children who heard the novel words as adjectives treated them as a property of the object. Children who heard a noun for an unfamiliar object generalized that name to other objects in that category more often than those who heard a noun for a familiar object. Conversely, children who heard a noun for a familiar object chose the named object more often than did those who heard a noun for an unfamiliar object. Thus, syntactic arrangement and word-object familiarity appear to be factors in contributing to how children as young as two years acquire the meaning of words.

Assuming that children use the mutual exclusivity rule to identify an object when the name of another object is known, will they continue using the rule when faced with an array of already named objects? Golinkoff, Hirsh-Pasek, Lavalley, and Baduini (1985) examined this issue with 30-month-old children who were presented with an unfamiliar word and then asked to choose a novel object from an array that included three additional famil-

iar objects. That the children selected the novel object was interpreted as supporting the hypothesis that the mutual exclusivity rule applied to a collection of familiar and unfamiliar word-object relations.

Carrying a similar line of inquiry further into the language learning process, Golinkoff, Hirsh-Pasek, Baily, and Wenger (1992) examined the use of lexical principles in acquiring new name-object relations in adults and children, the latter ranging in age from 28- to 32-months. The experiment was designed to determine if subjects would (a) attach a novel word to an unfamiliar object and (b) generalize the newly acquired word-object relation to a new exemplar. Two nearly identical experiments were conducted, the first with adults and the second with children.

Each experiment consisted of four distinct and rather complicated phases. In the first phase, subjects were presented with one of two words, familiar or unfamiliar, and were then given four objects to choose from. One novel, one familiar and related to the familiar word, and two other familiar objects. In the second phase, a novel word was presented, with the subjects being asked to choose an object from an array of four objects: two objects they could name, and two objects that they could not name, one of which was previously paired with the novel name but colored differently, and the second being an entirely new object. In the third phase, subjects were presented with a second novel name, and once again were presented with an array of four objects, two that they could name, one novel object that had been paired previously with the first novel name, and a second novel object. The fourth phase was a replication of the second, with the word presented being the same one that was used in the third phase. A third experiment involving only the children followed essentially the same procedures but with one minor change, namely, controlling for responses due solely to the novelty of the object. These procedures are shown in Table 3.

The adults' performances were uniformly consistent with the use of the

Table 3

Mutual exclusivity and extensions.

TRIAL TYPE	STIMULI	OUTCOMES
Mutual Exclusivity	NSa (NCa, KC, KC, KC)	Ss Choose NCa
Novel Comp. Diff Only in Color	NSa (NCa, KC, KC, KC)	Ss Choose NCa of Diff Color
2nd Novel Sample Introduced	NSb (NCb, NCa, KC, KC)	Ss Choose NCb
Novel Comp. Diff Only in Color	NSb (NCb, NCa, KC, KC)	Ss Choose NCb of Diff Color

mutual exclusivity rule across all four phases, whereas the children's performances were consistent with the use of the mutual exclusivity rule roughly three-quarters of the time. In short, all adults and most children not only used the rule, but also generalized from the newly learned relations to different sets of words and objects.

Summary

The cognitive literature offers some important findings on mutual exclusivity. The first is that procedures which incorporate sets of familiar and unfamiliar words and objects are more effective in teaching word-object relations than those that do not. Second, a variety of controlled studies have provided evidence for the use of the mutual exclusivity rule with both adults and children as young as two years.

A third area that cognitive psychologists have investigated is the use of the mutual exclusivity rule when the object being named already has a label. Under these conditions, subjects appear to readily apply an unfamiliar word to a salient quality or feature of a familiar object. The rule has also been related to other information that children have acquired, such as hierarchical structures and cross-linguistic terminology. Finally, rule usage appears to be readily generalizable; indeed, not only does introducing novel word-object relations have no affect on previously acquired relations, but such prior learning appears to actually facilitate more and varied instances of rule use.

Many questions of both a conceptual and empirical nature remain to be examined in this literature. For example, does using the mutual exclusivity rule reveal the maturation of innate structures and functions, and if so, what programs of research, psychological or otherwise, might be mounted to disclose their nature? Clearly, the environment must play a role; what specifically is its role, or more to the point, what combination of learning history and present circumstances either facilitates, inhibits, or otherwise affects rule usage? These and a host of similar issues reduce to necessity and sufficiency questions which can be expected to form the basis for further conceptual and basic empirical work. In addition, applications to education and rehabilitation can be anticipated in view of the significance of this literature for the acquisition and elaboration of language.

EXCLUSION

Behavior analysis has its own set of assumptions, among them being that behavior is a legitimate subject matter in its own right (Day, 1992; Skinner, 1938). The primary concepts and principles include learned and unlearned relations between environment and behavior, subdivided between respondent and operant functional relations. The sorts of behaviors referred to as cognition, thinking, problem solving, and the like are viewed as classes of behaviors no different, in principle, from the observable interactions between an organism and its environment (Skinner, 1974).

The operant paradigm has been especially powerful in terms of accounting for relatively simple classes of learned behavior; it also presents a theoretically consistent and coherent account of complex human behavior (Skinner, 1945, 1957, 1986). One such class of events, "emergent stimulus relations" has been examined by behavior analysts (e.g., Skinner, 1957). It has only been in the last two decades, however, that behavior analysts have constructed a conceptual framework capable of dealing with these phenomena (e.g., Hayes, 1991; Sidman, 1992). At present,

one type of "derived" stimulus relation that pertains to the development of novel behavior-environment interactions is the process known among behavior analysts as exclusion.

Exclusion has been of interest to behavior analysts because of its seemingly close relation to stimulus equivalence (Hayes & Hayes, 1989). Commonalities between exclusion and equivalence include (a) the appearance of novel responding that has not been directly reinforced, (b) the creation of new "higher order" conditional discriminations, and (c) the close connection to verbal behavior. Exclusion has also stimulated interest due to its applied implications (McIlvane & Stoddard, 1981; Stromer, 1986; de Rose, de Souza, Rossito, & de Rose, 1992). The first two areas covered in this section examine exclusion procedures in which the sample is novel (Exclusion I) and exclusion procedures in which the sample is known (Exclusion II). The final area covers the research relating exclusion to equivalence.

Exclusion I

The first behavior-analytic research on exclusion was conducted by Dixon (1977). She examined the exclusion of a trained choice and the subsequent selection of an untrained choice in response to an untrained spoken word as an indication of control by spoken words in adolescents identified as having either borderline or moderate retardation. The methods included (a) training conditional discriminations, (b) test sessions that probed for exclusion, and (c) probe sessions that sought evidence for control by spoken words. These procedures, which are fairly standard in studies of exclusion, are shown in Table 4.

Dixon (1977) found that all subjects selected the untrained choice on all exclusion probe trials, suggesting that they were responding "away from" the previously trained choice. Dixon also found, however, that 7 out of 8 subjects did not demonstrate control (i.e., matching) by spoken words on the discriminative probe sessions.

Table 4

Standard procedures in studies of exclusion.

TRIAL TYPE	STIMULI	PURPOSE
Matching to Sample	A (B)	Train Conditional Discrimination
Exclusion 1	X (Y, B) W (Z, B)	Test for Exclusion
Matching	X (Y, Z) W (Z, Y)	Stimulus Class Formation

Dixon's (1977) study indicated that individuals may exclude on the basis of a previously trained stimulus choice and that such responding does not necessarily lead to the acquisition of new conditional discriminations. This outcome is counterintuitive in that subjects who have a history of receiving reinforcement for making a particular choice may actually avoid that choice under these procedures.

Dixon's (1977) study was systematically replicated by McIlvane and Stoddard (1981). The subject in this study was a 25-year-old institutionalized male. The primary differences between this study and Dixon's were the level of retardation of the subject – in this case, profound – and the use of actual food instead of letters as comparison stimuli. In the first part of the experiment, which was a direct replication of Dixon's methods, the subject, after matching-to-sample training, excluded the known comparison, selecting instead the novel comparisons when given novel samples. As with Dixon's results, however, the subject did not show matching between the novel sample and the initially selected novel comparison stimulus when probed for this relationship.

The second part of McIlvane and Stoddard's (1981) study examined whether a more lengthy and varied exclusion history would affect novel word-food relations while concurrently acquiring new matching-to-sample relations. Two new food names were trained simultaneously with the same procedures as above. This time, the subject not only demonstrated exclusion, but also new matching-to-sample performances. In the second phase,

these procedures were replicated using pictures of food instead of the actual food. Results of this portion of the study showed nearly errorless exclusion and matching performances. The authors concluded by noting that baseline training may be necessary for exclusion to occur, and that such training may produce an errorless and efficient teaching method for individuals with language deficits.

Exclusion II

As noted earlier, Exclusion II procedures are those that involve known samples. Research of this type has often focused on the nature of the control by the discriminative stimulus. The issue is whether performance in the matching-to-sample procedure is controlled by a positive relation between the sample and correct comparison (S+), a negative relation between the sample and the incorrect comparison (S-), or both (Carter & Werner, 1978).

In a two-part study addressing this issue, Stromer and Osborne (1982) investigated whether four adolescents with developmental disabilities responded on the basis of positive stimulus relations (S+) or on the basis of negative stimulus relations (S-). Subjects were trained on two conditional discrimination tasks and were subsequently probed for symmetrical (i.e., $A = B$ & $B = A$) responding to two stimulus classes. Positive stimulus relations were examined by presenting a known sample and one comparison from the same class, along with a novel comparison. Subjects reliably chose the comparison from the same class, thus demonstrating control by the positive stimulus relations. Control by the negative stimulus relations was examined by presenting a sample from one stimulus class while simultaneously presenting two comparison stimuli, one belonging to a second stimulus class while the second was a novel stimulus. Stromer and Osborne's subjects reliably chose the novel stimulus, thus suggesting a role for both positive and negative stimulus relations in exclusion. These procedures are illustrated in Table 5.

Table 5
Type II exclusion procedures.

TRIAL TYPE	STIMULI	PURPOSE
Matching to Sample	A (B, D) C (D, B)	Train Conditional Discrimination
Symmetry Test	B (A, C) D (C, A)	Test for Symmetry
S+ Relation	A (B, X) C (D, Y)	Demonstrate S+ Relation of Sample
S - Relation	A (Y, D) C (X, B)	Demonstrate S - Relation of Sample & Exclusion

In Stromer and Osborne's (1982) second experiment, nine male adolescents with developmental disabilities were taught two successive conditional discriminations ($A=B$, $B=C$), and were then successively tested on symmetry ($B=A$), transitivity ($A=C$), and symmetrical transitivity ($C=A$). Following these tests, the subjects' responding were shown to be under the discriminative control of positive and negative stimulus relations in the new equivalence relations. What was absent in Stromer and Osborne's study was a further examination of whether or not new stimulus classes were generated from the exclusion procedures.

What is striking about the exclusion just described is that in these instances the sample was not novel, as in previous studies, but belonged instead to a previously established stimulus class. Hence, exclusion does not seem to depend on novelty, a finding that has been systematically replicated (McIlvane & Stoddard, 1985). A distinction is thus made (see McIlvane & Stoddard, 1985) between instances of exclusion where both the sample and comparison stimuli are novel (Exclusion I), and instances where the sample already belongs to an established stimulus class (Exclusion II).

McIlvane, Kledaras, Munson, King, De Rose, and Stoddard (1987) studied the nature of controlling relations in conditional discrimination and matching by exclusion with normal adults. The questions posed included whether the respond-

ing was based upon S+ or S- relations, whether exclusion would occur if each stimulus selected was conditionally related to more than one sample stimulus, and what training procedures make exclusion more or less likely.

What was unique in the McIlvane et al. (1987) experiment was their method for training and testing. As in the literature on equivalence (e.g., Sidman & Tailby, 1982), exclusion has been examined with a matching-to-sample procedure involving two or more comparison stimuli. McIlvane, Withstandley, and Stoddard (1984) noted that previous studies examining the nature of sample-stimulus relations shared common methodological problems, namely, the presence of unnecessary stimuli that might distract the subject, thereby affecting performance. With this in mind, McIlvane et al. (1987) used a single-comparison procedure. These procedures (shown in Table 6) appear to allow direct demonstration of both S+ and S- relations, while simultaneously simplifying the analysis of their respective control over responding (McIlvane et al., 1987).

Table 6

Examining the nature of control by exclusion.

TRIAL TYPE	STIMULI	PURPOSE
Matching to Sample	A (B, D) C (D, B)	Train Conditional Discriminations
S+ Relation	A (B, =)	Demonstrate S+ Relation of Sample
S- Relation	C (==, B)	Demonstrate S- Relation of Sample

Findings in the first experiment suggested that normal adults' responding in conditional discrimination tasks may be under the control of both S+ and S- relations.

In their second experiment, McIlvane et al. (1987) found that when subjects (8 of whom had been in the first experiment and 6 of whom were new) were shown a novel sample, a defined (i.e., known) stimulus, and an undefined (i.e., novel) stimulus, they consistently chose the undefined stimulus, thereby exhibiting exclusion. Experi-

ments 3 through 5 investigated the effects of relating comparison stimuli to one, two, or four sample stimuli. The effects of an aversive contingency on exclusion were also examined. Results showed that exclusion occurred regardless of whether the comparison stimulus was related to one or more sample stimuli. With respect to the aversive contingency, it was found that the word "wrong" appearing on a computer monitor effectively suppressed exclusion performance. This effect did not generalize, however, until the aversive contingency occurred under other conditions.

Exclusion and Equivalence

We now turn to an evaluation of the research on the relation between exclusion and equivalence. Some of this literature has already been cited in the context of reviewing other issues (e.g., Stromer & Osborne, 1982). In an extension of Dixon's (1977) study, Stromer (1986) examined the use of visual arbitrary matching-to-sample procedures in fostering exclusion performances with eight adolescents with developmental disabilities. This study examined whether known stimuli used as samples on the initial training would also serve a similar function as comparison stimuli in exclusion tests. Subjects were given arbitrary matching-to-sample training on two sets of stimuli, and were then tested for symmetry. Next, comparison stimuli were assessed for preference and assigned to comparison stimuli according to the least preferred. These procedures are shown in Table 7.

Subjects in group 1, all of whom were exposed to the original comparison stimulus in the exclusion trials, demonstrated exclusion. Subjects in group 2, all of whom were exposed to the original sample as a comparison in the exclusion trials, did not show exclusion; instead, they chose the stimulus that had previously served as the sample stimulus. This is especially interesting in that the subjects demonstrated symmetry on the sample and comparison stimuli prior to the test for exclusion. The upshot of this finding is that the exclusion of a stimulus might necessitate a particular

Table 7
Symmetrical control by exclusion.

TRIAL TYPE	STIMULI	PURPOSE
Matching to Sample	A (B)	Train Conditional Discrimination
Exclusion	X (Y, B)	Test for Exclusion
Exclusion by Symmetrical Control	W (Z, A)	Test for Exclusion

training history in which the same stimulus serves as a comparison.

Stromer (1989) replicated his 1986 study, employing normal adults and children as subjects. Unlike the previous research, subjects demonstrated exclusion when the sample in the original conditional discrimination served as a comparison, thereby showing symmetrical control of the sample and comparison stimuli. In addition, four out of the six subjects demonstrated new conditional discriminations. This study is especially noteworthy in its demonstration of the relationship between exclusion and equivalence.

Exclusion has also been studied in applied settings, particularly in training language skills. The role of equivalence in reading and other language skills has long been recognized by behavior analysts (Mackay & Sidman, 1984; Matos & d'Oliveira, 1992; Sidman & Cresson, 1973). The role of exclusion in reading has also captured the attention of researchers in this area.

In one of the first studies relating exclusion to reading, McIlvane, Bass, O'Brien, Gerovac, and Stoddard (1984) replicated previous studies in exclusion (Dixon, 1977; McIlvane & Stoddard, 1981), extending the exclusion procedures to training manually signed food names. The significance of these findings was that not only was correct responding made to the signs, but the same signs were also produced when food served as the sample stimulus. In other words, the exclusion training brought about the signed equivalent of naming.

Using economically disadvantaged "at-risk" children as subjects, de Rose, de

Souza, Rossito, and de Rose (1992) studied the effects of using an auditory-visual matching-to-sample procedure on (a) the acquisition of reading skills, (b) the formation of stimulus equivalence relations showing reading comprehension, and (c) the acquisition of a repertoire of minimal units involved in reading untrained words. Initial stimulus classes (e.g., dictated word-to-picture and picture-to-name) were enlarged by exclusion procedures in which the subjects learned new stimulus relations (e.g., dictated words to printed words). These procedures are shown in Table 8.

Table 8
Generating equivalence through exclusion.

TRIAL TYPE	STIMULI	PURPOSE
Matching to Sample	A (B, D) C (D, B)	Train Conditional Discrimination
Exclusion 2	A (X, D) C (Y, B)	Test for Exclusion
Matching	A (X, Y) C (Y, X)	Stimulus Class Formation
Equivalence	B (X, Y) D (Y, X)	Equivalence by Exclusion

These training procedures produced new equivalence relations (e.g., printed words to picture, picture to printed word, printed word to name, and name to printed word). de Rosa et al. (1992) concluded that their findings supported the account of reading and stimulus equivalence developed by Sidman and his colleagues (Mackay & Sidman, 1984; Sidman & Cresson, 1973). The children in this study learned to produce the names of training words after exclusion training. Finally, this procedure seemed to constitute an important element of a successful program to teach children to read.

Summary

The behavior analytic literature has demonstrated the following properties of exclusion. First, exclusion may be reliably demonstrated across adults, children, and individuals with mild-to-severe developmental disabilities. Second, two types of

exclusion have been demonstrated: Exclusion I, wherein the sample is novel, and Exclusion II, wherein the sample is known. It has also been shown that multiple samples may be paired with one comparison and exclusion still occurs. This has also been reversed: one sample has been paired with multiple comparison stimuli, and again, exclusion is shown.

Third, in matching-to-sample procedures, subjects may respond to S+ or S- relations alone or in combination. Finally, behavior analysts have examined some of the relations between exclusion and equivalence. It has been shown that symmetrical relations among stimuli may be demonstrated without both stimuli functioning equivalently in occasioning exclusion. Research has also shown that procedures using exclusion can generate equivalence among stimuli. It has also been shown that exclusion procedures have important educational applications, especially with training basic language skills.

Several important questions remain to be examined in the behavior-analytic literature on exclusion. Perhaps the most important is why exclusion procedures do not generate new conditional discriminations as reliably as do equivalence procedures. The unreliable generation of new stimulus classes may be related to the number of stimuli subjects are excluding. A second important question concerns the type of learning history required to promote exclusion and whether the procedures in effect actually train those histories or merely demonstrate their respective effects. The exact nature of the relation between exclusion and equivalence also remains unclear. Both can generate new stimulus classes and both appear to be effective strategies for training basic verbal skills to individuals with various intellectual delays. Whether either or both will require new behavior principles or are reducible to extant behavioral principles remains to be seen. And, as with equivalence, the question arises as to whether exclusion is a type of behavior that only verbal organisms emit (Hayes, 1989).

RESEARCH AND COLLABORATION

Our interpretation of the mutual exclusivity and exclusion research is that, just as there are certain themes which cut across the two literatures, there are also certain themes which divide them. We pointed earlier to a few of the latter themes, mentioning that differences in conceptual orientation and methodological strategy render any comparison between cognitive and behavior analytic research on any topic difficult, if not impossible. How this problem reveals itself in the mutual exclusivity and exclusion research is illustrated when, for example, cognitive workers infer from a statistical analysis of grouped data that a decidedly grammatical, and therefore uniquely human rule having phylogenetic origins is deployed in the service of acquiring new and varied mental representation for words and objects. The approach of behavior analysts, in sharp contrast, is to appeal to identifiable variables which lie within an individual's lifetime of interacting with its environment which exert control over observable behavior that, although verbal, can be accounted for in principle by invoking empirically derived concepts obtained largely from nonhuman, single-case experimentation.

In light of the differences which divide cognitive and behavior analytic workers on so many fundamental issues, it is easy to see that not only is it unlikely to find one reading the other's work in areas such as mutual exclusivity and exclusion, but were they to do so, the tendency would be to discount the other's work as irrelevant. Our view is that despite the differences, or perhaps because of them, it is incumbent on researchers in these two areas in particular to set aside the time to become well-versed in each other's work, and also to set aside the sorts of biases that historically have mitigated against cross-fertilization.

As behavior analysts, we are naturally most interested in what we can learn from the mutual exclusivity research that could aid us in designing experiments which shed further light on relational responding in general, and on exclusion in particular. We are also interested in application. These

issues form the basis for the following discussion, where we will see, first, that the mutual exclusivity literature suggests several new lines of inquiry for behavior analytic research, and second, that it is in the area of application that behavioral and cognitive psychologists might collaborate.

Research

Stripping away all the conceptual, methodological, interpretive, etc. impedimenta to a functional analysis, one is left with a variety of findings from the mutual exclusivity literature that behavior analysts can use to enliven their own research. Two areas seem especially promising. The cognitive literature on mutual exclusivity has demonstrated that names or labels can be attached to already named objects. In this instance, cognitive psychologists suggest that this occurs due to the different categories that each name is related to. For example, children learn to call the same object both a dog and an animal due in part to the different categories each name falls into. The second important finding is that how a word is syntactically arranged (as a noun or adjective) affects the use of the mutual exclusivity rule in treating that name as a category or quality for the object. For example, saying "that is a zog" versus saying "that is a zog one" affects whether the name is applied to the object itself or instead to a quality of that object. In both cases just described, there is no equivalent research in exclusion.

Just how would behavior analysts go about similar investigations? Let us use, as an example, Markman and Wachtel's (1988) study on how the mutual exclusivity rule might be affected when applied to already named objects. This study is similar to how behavior analysts might proceed in teaching stimulus classes or concepts. The implication here is that when teaching concepts (e.g., size, color, shape), the first important step would be teaching the names for the objects to be used in the training. For example, when teaching children to differentiate by colors, the name for the colored item would be first taught, and then the colors themselves. Procedures

of this sort would nicely complement the basic formula laid out by Skinner (1957) for training concepts or abstract facts. In any case, such research would be a variant of the exclusion procedures and would provide further understanding of class and concept formation.

A second important area of research in mutual exclusivity that has important implications for research in exclusion is how noun and adjective usage may be related to whether the object being named is familiar or unfamiliar. In Taylor and Gelman's (1988) study, how words are syntactically arranged, and the relative familiarity of the objects, affected the use of the mutual exclusivity rule. What does this mean to behavior analysts? The implications for behavior analysts are that the parameters of research can be readily extended to include a functional analysis of syntax and how it relates to the process we know as exclusion. Another important research area to be spun off the cognitive literature on mutual exclusivity is in examining the host of contextual cues that occasion certain types of exclusion practices. Finally, other research on how multiple responses are established by single objects could be readily explored from the existing mutual exclusivity literature.

Research, however, is only one aspect of science. Another component of science is application. Behavior analysts have always had one eye cast toward a technology of behavior change while cognitive psychologists have been primarily concerned with theory. It is suggested that the firmest grounds for collaboration are to be found in applied work. It is to this effort that we now turn our attention.

Collaboration

Both cognitivists and behaviorists are interested in showing how mutual exclusivity and exclusion further our understanding of how linguistic behavior is acquired and elaborated, and how it might be taught. Behavior analysts and cognitive psychologists can find common ground in utilizing their research in applied settings. In particular, research on mutual exclusiv-

ity and exclusion offer important fundamentals in terms of teaching basic verbal receptive skills such as word-object relations, concepts, as well as expressive language skills. In this section, we explore two such possibilities for collaboration between cognitive psychologists and behavior analysts in bringing together the research on mutual exclusivity and exclusion for applied work.

The first area that collaboration can be productive is in training important language skills. Procedures derived from the mutual exclusivity and exclusion literatures could be used to teach (a) word-object relations (receptive language skills), (b) object-word relations (expressive language skills), (c) reading, (d) categories of names, and (e) a second language to name just a few of the possibilities. Further use of these procedures could be found in teaching parts of speech, to teach concepts (e.g., size, color, shape), as well as syntax. In other words, many of procedures that are now currently in place may be made even more effective with the literature that has been reviewed so far.

The second area for mutual collaboration is that of language remediation training. The acquisition or understanding of the basics in terms of nouns, verbs, etc. may not be readily acquired by everyone, especially individuals with developmental disabilities. While behavior analysts have already begun some work of this sort (see de Rose et al., 1992), the cognitive literature on mutual exclusivity offers further suggestions to facilitate remediation efforts on more complex levels (e.g., class or concept formation, syntax, etc.).

CONCLUSION

Fundamental differences have partly contributed to the long history of misunderstanding between the two positions. This misunderstanding has often been accompanied by mutual antagonism. When cognitivists criticize contemporary behavior analysis, what they are typically criticizing is not the radical behaviorism of Skinner but the classical behaviorism of

John B. Watson (Day, 1992; Morris, Higgins, Bickel, & Braukmann, 1987). Conversely, cognitive psychology is increasingly addressing issues that behaviorists have long felt to be their own position (e.g., pragmatics in language, the role of context, etc., see Marr, 1984).

To some extent, an interaction of sorts has begun. Behavior analysts frequently cite literature in cognitive psychology (e.g., McIlvane et al., 1987); to our knowledge, cognitive psychologists citing behavior-analytic research has yet to occur.

Finally, mutual exclusivity and exclusion appear to be essentially the same phenomenon. The use of different terms and research strategies and tactics is a reflection of different sets of assumptions, not different phenomenon. We have shown how behavior analysts can make use of the procedures found in studies of mutual exclusivity both as the basis for further basic research as well as to use as a foundation for collaboration with cognitive psychologists in applied settings.

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